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Conformance testing trials on ERMES receivers

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Abstract

A test system for checking the receivers of the digital pan-European paging system ERMES for conformity to the standard specification for air interface and receiver operation has been developed according to the ISO 9646 standardized methodology for conformance testing services. The test procedures, various test setups and test execution software, implemented and integrated in a fully operational test system, are described in this paper. Complete test suites have been carried out on ERMES receivers. A part of the results of test trials is listed here, demonstrating the test system functionality.

Keywords

Paging system, ERMES, conformance testing

1 INTRODUCTION

Conformance testing is the verification that an implementation meets the formal requirements of the referenced standard. Its primary objective is to ensure interoperability among different product implementations. The need for a variety of interconnection and interoperability schemes among different implementations has led to the establishment of a standardized methodology and modeling approach for the description of the operation of the introduced systems and services, namely the Open System Interconnection (OSI) model.

B. Baumgarten et al. (eds.), *Testing of Communicating Systems*

The operational capabilities of any system or commercial product, derived through the realization of a new concept, are fully described in the relevant standard specification which may be considered as national, international, licensed, etc. Such implementations, which usually come from various manufacturers and, sometimes, even technologies, can be tested uniformly to determine whether they conform to these standards. Consequently, authorized organizations should ensure the existence of accredited laboratories to provide Conformance Testing Services (CTS) for the industry.

In this paper, we describe the development of a Conformance Test System* for the air interface and receiver operation of the European paging system ERMES (European Radio MEssage System), as specified by the European Telecommunications Standards Institute (ETSI) (prETS 300 133-1, prETS 300 133-4, prETS 300 133-5, 1991). In particular the test procedures, with the various test setups and the test execution software, are described. Finally, a detailed list of results, obtained from trials covering key test cases, is included.

2 ERMES OVERVIEW

ERMES is allocated on a common frequency band throughout Europe comprising sixteen 25 kHz spaced channels between 169.425 MHz and 169.800 MHz. The ERMES network operates at a data rate equal to 6.25 kbits/s, which is reduced at a symbol rate equal to 3.125 kbaud by the use of 4-PAM/FM modulation. Normally, an ERMES receiver will receive calls on a single channel used by its home network. However, it will scan all the 16 channels in the case when that single channel is lost (e.g., during roaming).

The structure of the ERMES transmission protocol is based on a sequence of 60 minutes total duration comprising 60 paging cycles. Sequences are coordinated with the UTC (Universal Time Coordinated) so that on the hour a new sequence commences. Each cycle (one minute long) is divided into five subsequences commencing at 12 second intervals. Each subsequence is further divided into 16 batches and each batch has four partitions (synchronization, system information, address and message partitions). The first fifteen batches in every subsequence have a length of 154 codewords and the final batch has a length of 190 codewords (standard information unit of 30 bits length). The receiver population is divided into 16 groups and each receiver is allocated to one of the 16 batch types according to the 4 least significant bits of its basic Radio Identity Code (RIC).

The ERMES system supports the following four paging categories:

- Tone only: the receiver shall respond to at least one of eight alert types.
- Numeric: the receiver shall provide for the reception of a 20 digit numeric message.
- Alphanumeric: the receiver shall provide for the reception of a 400 character text message.
- Transparent data: the receiver shall provide for the reception of an arbitrary data message.

In addition, a wide range of supplementary services is also supported, e.g., acknowledgement, protection against loss of messages, three levels of priority, long messages.

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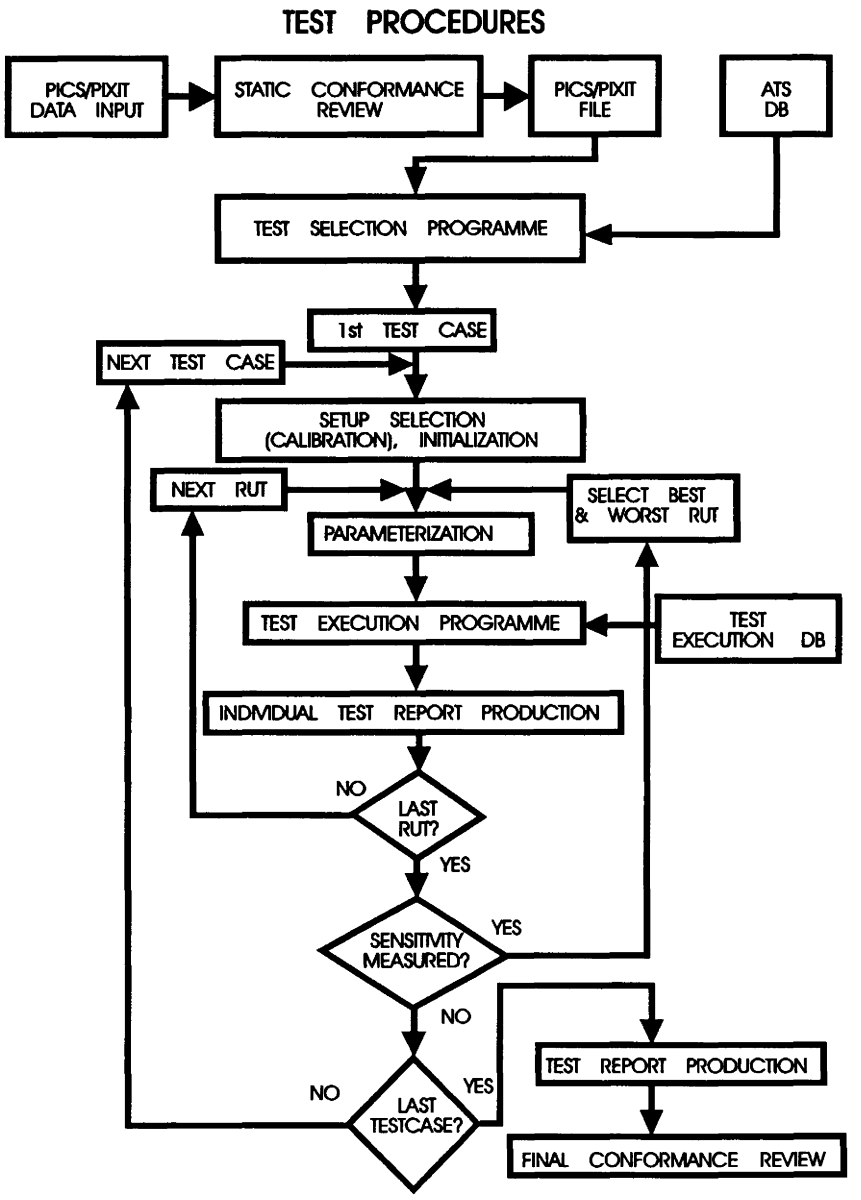


Figure 1 Complete Test Procedure Flow Chart.

3 TEST PROCEDURES

The procedures carried out by the test system in order to run the tests are shown in the flow chart of Figure 1. A more detailed description is given in (CTS-3 ERMES Project 45067, Deliverable 3, 1992) and (Dangakis, 1992). PICS (Protocol Implementation Conformance Statement) and PIXIT (Protocol Implementation eXtra Information for Testing) contain the required information for test selection and parameterisation (CTS-3 ERMES Project 45067, Deliverable 5, 1992). The data included in the PICS and PIXIT proformas will be stored in a file in order to allow an automated selection and parameterisation procedure to be performed. The programme that enables the data input performs also some consistency checks ("static conformance review"). The whole ERMES Abstract Test Suite (ATS) is organized in an ERMES database (CTS-3 ERMES Project 45067, Deliverable 1, 1991). The "test selection programme", based on the PICS and PIXIT information, handles the ATS database and produces the selected ATS containing all the test cases relevant to the particular Receiver Under Test (RUT). For each selected test case, the file produced by the "test selection programme" contains all the necessary information for the test execution. First the setup, that is appropriate for the particular test case under consideration, is selected and the necessary installation and preparations are done (ETSI PT8, Final Report, 1990).

Several parameters must be specified before running a test. Some of them are derived from the RIC that is specified, for each one of the six receivers to be tested, by the ERMES standard (prETS 300 133-5, 1991). Most of the test cases require that only the best and the worst (with respect to the measured average usable sensitivity) receivers of the six supplied shall be used. This means that the sensitivity measurement tests shall be carried out first, and then their results shall be taken into account during the test case selection and parameterisation. Some parameters are specified according to the input information from PICS / PIXIT. Others are set according to the requirements of the particular test case and their values are retrieved by the "test execution programme" from the "test execution database". Finally, there are some parameters that need to be set and updated in real time, while running the tests.

The different setups that are used and the "test execution programme" (software tool actually running the tests) are described in the next two sections.

4 SETUPS OF THE TEST SYSTEM

According to the standards (prETS 300 133-5, 1991), some tests are carried out on an Open Area Test Site (OATS) while the rest are carried out using a test fixture (TEM-cell). For extreme test conditions a test fixture placed in a climate chamber is also required. So, the following four setups were used in the test system:

- setup A for OATS measurements;
- setups B, C and D for measurements using a TEM-cell.

The block diagrams of these setups are given in Figure 2, where a RF signal generator simulates the ERMES base station. The calibration of the test site and test fixture (ETSI PT8, Final Report, 1990) establishes a relationship between the output level of the RF signal

generator and the field strength applied to the RUT. This relationship for each one of the setups is given below.

Test setup A

The following formula was applied, giving the field strength e at the RUT position:

$e = u + AF + AL + CL$ (dBμV/m)

where

u : substitution antenna output measured with spectrum analyzer (dBμV)
AF=12.9 dB : substitution antenna factor
AL=0.2 dB : substitution antenna loss
CL=0.9 dB : cable loss, from substitution antenna to spectrum analyzer

Test setup B

According to the calibration of the TEM cell, the average usable sensitivity (dBμV/m) equals to the average of recorded values minus 9 dB.

Test setups C & D

RF generator A (wanted signal) output level, r, adjustment:
The results from the measurements of the average usable sensitivity, in the OATS and the test fixture, are used to calculate the r (dBμV) corresponding to a field strength of 25 dBμV/m, in the test fixture. The following formula was applied:

$r = l + d + A$

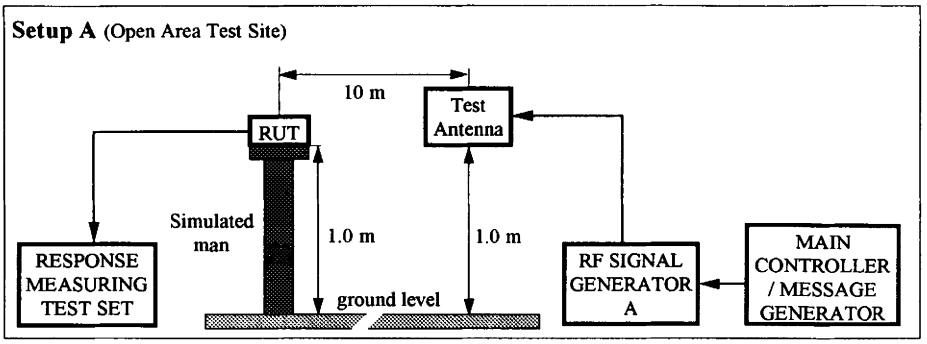
where

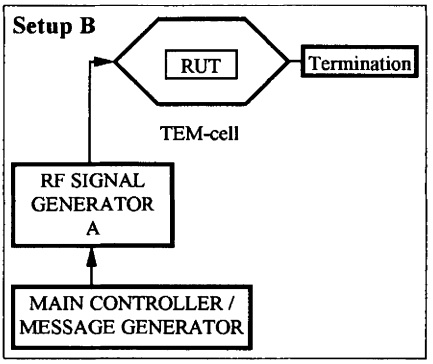
l: RF Generator A output level (dBμV) obtained from the measurement of the average usable sensitivity in the test fixture.
d: Difference (in dB) between the measured average usable sensitivity in OATS and the reference figure (25 dBμV/m).
A: Additional attenuation (in dB) due to combiner and extra cables (equal to 7.7 dB for setup C and to 10 dB for setup D).

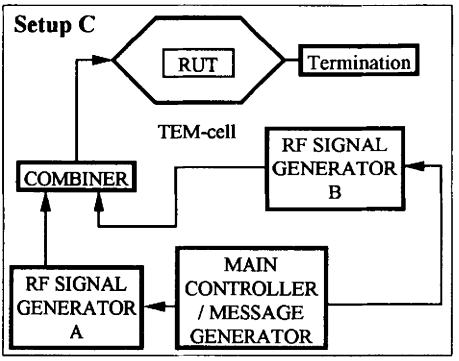
5 TEST EXECUTION PROGRAMME

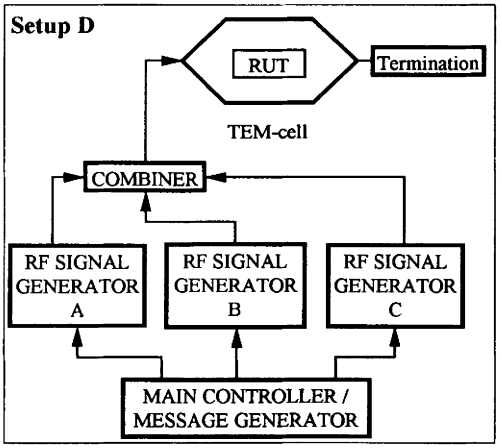
This software runs on the main controller (PC) and communicates with the other devices through digital I/O, serial and IEEE interface cards. Before running a specific test case, it initializes the setup by:

- Reading the ambient temperature and relative humidity values and verifying that they are within the limits specified by the standard for normal test conditions.
- Setting the climate chamber to the extreme temperature and relative humidity values specified by the standard for extreme test conditions (if needed).









Equipment used in setups	Manufacturer Type
Open Area Test Site	DEMOKRITOS
Simulated man	DEMOKRITOS
Antenna mast OATS	Anritsu MB19A
Message Generator	DEMOKRITOS
RF Signal Generator A	R / S SME-03
RF Signal Gen. B & C	R / S SMG
Antenna (ERMES signals)	EMCO 3121C
Antenna for substit. meas.	EMCO 3121C
RF combiner	R / S DVU4
TEM cell	DEMOKRITOS
Response Measuring Test Set	HP 8595A spectrum analyzer

Figure 2 Block diagram of Test System Setups and list of equipment.

- Setting the power supply voltage to the nominal or extreme (maximum or minimum) value.
- Setting the center frequency of the RF signal generator to the specified RF channel.
- Setting the RF signal generator output power level to the proper value.

During most of the considered test cases, the common and basic task next carried out by the test execution software is the transmission of a burst containing a message at a specified time slot (batch). In order to do this, the software must step through the following:

- It forms the information content that is to be transmitted, by combining information retrieved from PICS / PIXIT and the test execution database or entered by operator.
- Time related information (date, hour, cycle, subsequence and batch numbers) is also inserted and updated in real time.
- Error correction coding, where the information bits are grouped in codewords, is done followed by codeword interleaving.
- The resulting bit-stream buffered in the PC RAM, is then passed, at the nominal bit-rate and through the digital I/O card, to the modulation data input of the RF signal generator performing ERMES modulation. The software uses for synchronization a time reference obtained from a UTC source (Odetics GPStar).

The above steps, resulting in the transmission of an ERMES message (single batch transmission) at a specified RF channel frequency, may be repeated several times while running a single test case, depending on the requirements. This procedure is automatically repeated but, after each transmission, the software waits for the operator's input denoting if the response was successful or not.

The ERMES conformance testing services may be divided in two categories: the RF parameter tests and the protocol conformance tests (CTS-3 ERMES Project 45067, Deliverable 5, 1992).

The first category includes all test cases directly related to Radio Frequency operational characteristics of ERMES receivers. The value of the RF parameter under test is derived statistically from the RF signal levels recorded during repeated single-batch transmissions. This value is then compared with the corresponding verdict criterion, in order to assign the verdict (Pass or Fail) to the specific test.

To illustrate such a procedure, we consider, as an example, the test case concerning the measurement of average usable sensitivity that corresponds to a "message acceptance ratio of 80%", as defined in Annex A, subclause A.1.2. of (prETS 300 133-5, 1991). The software uses the algorithm shown in the flow chart of Figure 3. This procedure is repeated for the 8 positions, 45° apart, of the receiver. The corresponding average values of the generator output are determined and noted. Using the calibration of the test site, the 8 field strengths corresponding to the 8 average values are calculated and the average measured usable sensitivity is derived as a mean field strength.

The second category (protocol conformance tests) includes all test cases referred to the essential or optional features of ERMES receiver operation, with respect to its particular paging type. The test execution software manages more complex message transmissions covering multiple batches, subsequences (16 batches) and RF channels. In this category, generally, one message transmission occurs and the verdict is derived by comparing the receiver response to the expected one.

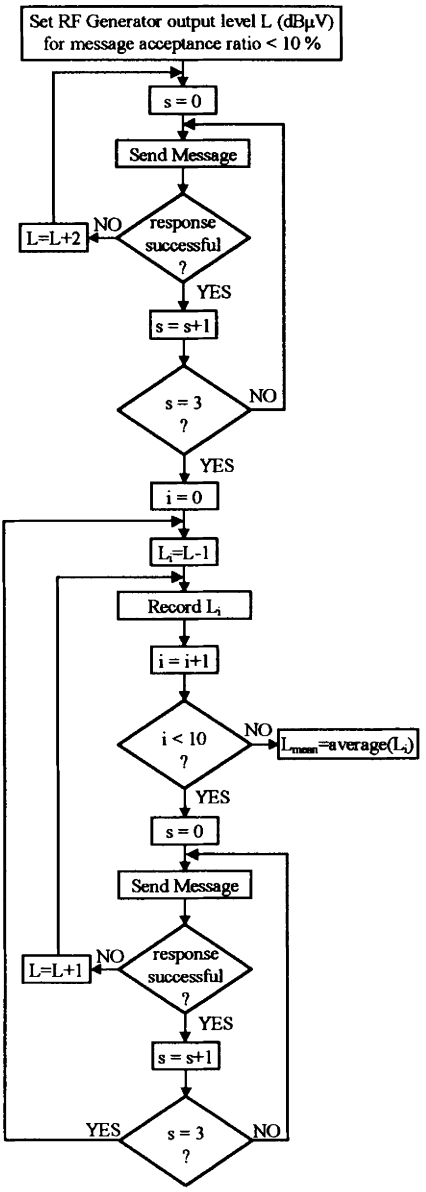


Figure 3 Flow chart of the algorithm for the implementation of a message acceptance ratio of approximately 80%.

Table 1 List of covered test cases with the corresponding ATS No. and setup

ATS No.	*SETUP*	*DESCRIPTION*
001-003	A	Average Usable Sensitivity channel 8
004-006	B	Average Usable Sensitivity channels 0, 8, 15
007-009	B	Average Usable Sensitivity with tx freq. offset
010-012	B	Average Usable Sensitivity (extr. conditions)
013-015	B	Average Us. Sens. (extr. cond.+freq. offset)
016-018	B	Average Usable Sensitivity channel switching
020-022	A	Usable Input Level Range
023-025	C	Co-channel Rejection
026-028	C	Adjacent channel Selectivity (norm. cond.)
029-031	C	Adjacent channel Selectivity (extr. cond.)
032-034	C	Spurious Response Immunity
035-037	D	Intermodulation Immunity
038-040	C	Blocking Immunity
044-046	B	First Message in Batch
047-049	B	Last Message in Batch
050-052	B	Message in Next Batch
053-055	B	Message in Last Available Batch
056-058	B	Tenure of Message
059-061	B	Two Messages in the Same Batch
062-064	B	Message in the next Subsequence
065-067	B	Message reception on all ERMES channels
068-070	B	Recognition of Zone Code
071-073	B	Two Messages in the Same Batch
080-081	B	Maximum length message
082-084	B	Alert (Normal operation)
085-087	B	Alert (Silent mode)
088	B	Termination of numeric messages
089	B	Termination of alphanumeric messages
090-095	B	Repeated Call Indication
096-098	B	Group Call
099-101	B	Tenure of Group Message
102-103	B	Low Battery Indication
111-113	B	RSVD bits
116-119	B	Indication of lost message
120-122	B	Urgent message indicator

Table 2 List of results for test cases concerning RF parameters measurements (alphanumeric paging category).

ATS No.	*Measured Value*	*Verdict Criteria*	*Verdict*	
			PASS	*FAIL*
022	4 correct messages out of 4	4 correct messages out of 4	✓	
025	7.6 dB	≤ 10 dB	✓	
034	79.2 / 83.2 dBμV/m	≥ 76 dBμV / m	✓/ ✓	
037	73.9 / 73.7 dBμV/m	≥ 70 dBμV / m	✓/ ✓	
040	103.4 /109.0 dBμV/m	≥ 84 dBμV / m	✓/ ✓	
003	21.8 dBμV/m	≤ 25 dBμV / m	✓	
006	22.7 / 24.3 dBμV/m	≤ 25 dBμV / m	✓/ ✓	
009	24.1 / 20.5 dBμV/m	≤ 25 dBμV / m	✓/ ✓	
012	No RUT response	≤ 31 dBμV / m		✓
015	No RUT response	≤ 31 dBμV / m		✓
018	No RUT response	≤ 25 dBμV / m		✓
028	54.8 dB	≥ 60 dB		✓
031	No RUT response	≥ 50 dB		✓

Table 3 List of results for test cases concerning Protocol Conformance tests (alphanumeric paging category).

ATS No.	*Verdict Criteria*	*Verdict*	
		PASS	*FAIL*
046	Correct reception without error	✓	
049	Correct reception without error	✓	
052	Correct reception without error	✓	
055	Correct reception without error	✓	
058	No reception	✓	
061	Correct reception of both messages without error	✓	
064	Correct reception without error	✓	
067	Correct reception on all ERMES channels without error	✓	
070	No reception	✓	
073	Correct reception of message 2 without error	✓	
081	Correct reception without error	✓	
084	Correct reception without error giving the appropriate alert	✓	
087	Correct reception without error (no audible alert)	✓	
088	Presentation of only the first 4 characters	✓	
089	Correct reception without error	✓	
095	Correct reception without error, giving a repeated call indication		✓
098	Correct reception without error	✓	
101	No reception of group message	✓	
103	≥ 1.08 V	✓	
113	Correct reception without error	✓	
119	The receiver shall indicate that messages are missing	✓	
122	Correct reception without error, with an urgent message indication	✓	

6 TEST RESULTS

When the execution of a test case has finished and a verdict (Pass, Fail) is assigned to it, the test results are stored. This information is updated at the end of execution of each test case and is used to produce the test report at the end of the test campaign (Figure 1).

The verification and the calibration of the ERMES test system is performed using the ERMES Reference Implementation (RI), (CTS-3 ERMES Project 45067, Deliverable 7, 1993). The ERMES RI is a device that consists a reference system implemented in accordance to the ERMES standard. It proves the equivalence of the testing tools as well as the functionality of the CTS centers, prior to approvals and commercial testing.

The ERMES test system presented here is currently operational in our laboratory. Test suites covering the test cases listed in Table 1 have been carried out on ERMES receivers coming from various manufacturers. In order to demonstrate the operation of the implemented ERMES test system, we present (in Tables 2, 3) the results of some test cases applied on a specific prototype ERMES receiver for alphanumeric paging category. The information that this receiver failed in some tests, could be useful in modification of the design of the particular product, in order to meet the ERMES standard requirements completely.

7 CONCLUSION

In this paper, the development of a Conformance Test System for the ERMES air interface and receiver operation was presented and the procedures for running the tests were described. Complete test suites have been carried out on ERMES receivers coming from various manufacturers and a list of indicative results was given, demonstrating the operation of the system in accordance to the ISO 9646 standardized methodology for conformance testing services (ISO/IEC 9646, 1993) and (EWOS / ETSI PT5, 1990).

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